Modeling of nutrient concentrations in the river Loktinka, Western Siberia

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Introduction

The investigated catchment area is the river Loktinka which is located in the southern part of the West Siberian Plain, in the forest-steppe vegetation region. The main land use in this area is agriculture, whereupon one of the most serious contaminant of the surface waters in the region are nutrients. The main input of nutrients comes from untreated runoff from agricultural fields and pastures.

Fig. 1: Location of the study area

This study presents the necessary data base and data preparation for applying the Geohydrological Analysis Model, developed by Prof. Kalinin, Tyumen State University, Russian Federation (1998) for the region. The model is based on "Runoff Forming Surfaces“ (RFS), which are distinct parts of the catchment characterized by a set of natural components such as land use, soil and elevation. These areas are relatively homogeneous and lead to the same parameters for representing the hydrological cycle.

The model will be used to simulate the water quality situation which was sampled during spring runoff in 2013, since most of the river's runoff - almost 80% - occurs during the snowmelt period.

Methods

Calculation of the runoff of nutrients from the catchment into the river requires three data blocks:

1. **Meteorological data** (monthly average temperature, monthly average snow reserves, monthly average relative humidity, monthly average precipitation, depth of soil freezing);
2. **Parameters of agriculture within the study area** (livestock population, amount of fertilizer applied);
3. **Runoff conditions of the catchment area** (can be obtained from the RFS map).

The first two blocks are available background information. The main task of setting up the Geohydrological Analysis Model is the mapping of the Runoff Forming Surfaces (RFS).

Results

Fig. 2, 3 and 4 show the results of the water sampling. The obtained results are important information about the actual nutrient distribution in the river Loktinka.

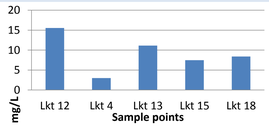


Fig. 2 Nitrate (NO3)

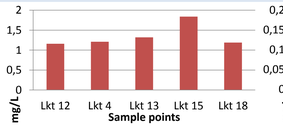


Fig. 3 Ammonium (NH4)

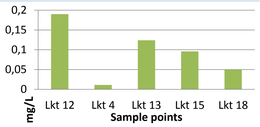


Fig. 4 Phosphates, PO4

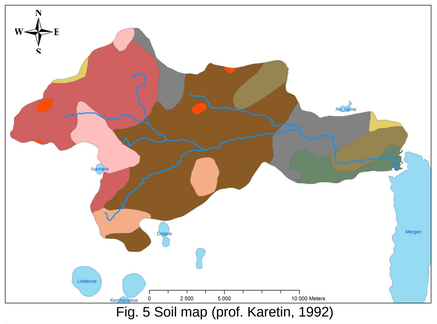
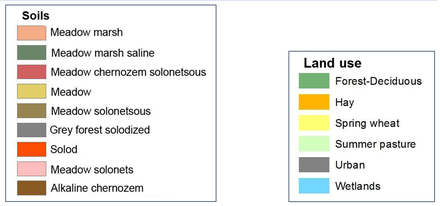


Fig. 5 Soil map (prof. Karetin, 1992)

The RFS map (Fig.8) is the result of an overlay of the maps shown in Fig. 5, 6 and 7



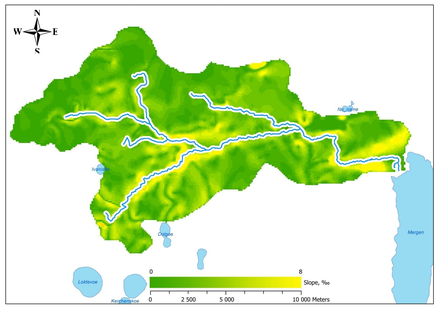


Fig. 6 Slope map (UralAeroGeodesy, 2010)

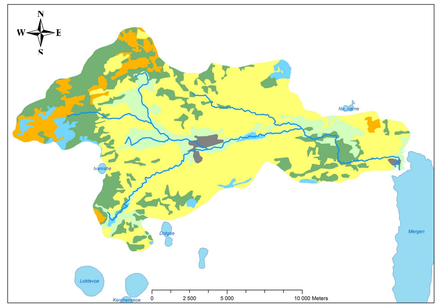


Fig. 7 Land use map (EFTAS and Kolychalov, 2012)

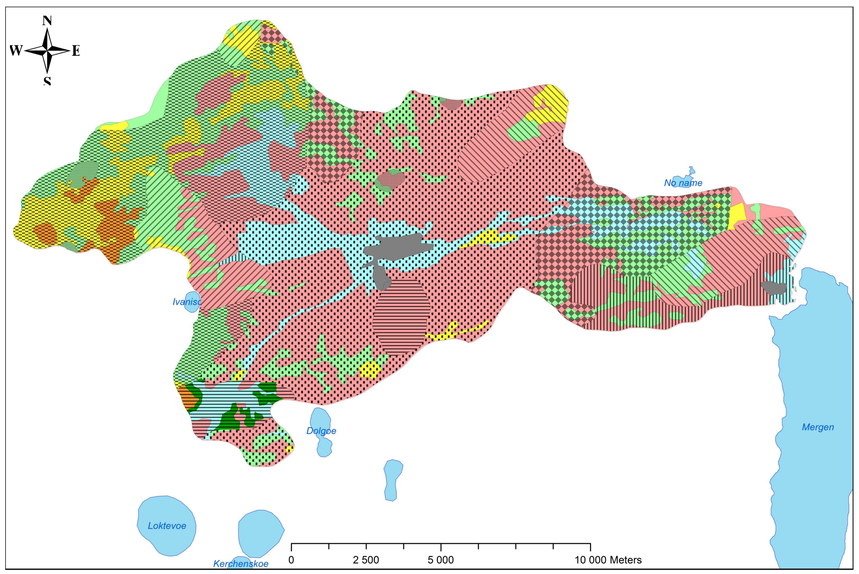


Fig. 8: Runoff Forming Surfaces map

№ RFS	Land use	Soil type	Mechanical composition	Area, km²	Slope, ‰	Symbol
1	2	3	4	5	7	8
-	Urban Territory	-	-	2,087	-	
1	Deciduous Forest	Solod	Medium-textured loam	0,819	1,1	
2		Meadow	Loamy clay	0,948	1,0	
3		Meadow marsh saline	Loamy clay	1,906	3,9	
4		Meadow solonets	Loamy clay	5,157	1,7	
5		Meadow solonetsous	Loamy clay	2,793	2,8	
6		Meadow chernozem solonetsous	Loamy clay	15,180	2,4	
7		Leached chernozem	Medium-textured loam	6,833	2,7	
8		Grey forest solodized	Medium-textured loam	8,302	2,3	
9	Forested Wetlands	Meadow marsh	Loamy clay	1,328	1,7	
10	Hay	Meadow	Loamy clay	0,547	0,8	
11		Meadow solonets	Loamy clay	1,138	2,0	
12		Meadow chernozem solonetsous	Loamy clay	10,180	1,3	
13		Grey forest solodized	Medium-textured loam	0,039	1,9	
14		Meadow solonetsous	Loamy clay	1,211	3,6	
15		Leached chernozem	Medium-textured loam	1,379	2,8	

1	2	3	4	5	7	8
16	Summer Pasture (Bottomland Meadow)	Meadow marsh	Loamy clay	2,283	2,4	
17		Meadow solonetsous	Loamy clay	0,714	2,2	
18		Meadow chernozem solonetsous	Loamy clay	4,248	2,3	
19		Leached chernozem	Loamy clay	10,140	2,1	
20		Grey forest solodized	Loamy clay	3,140	0,8	
21	Mixed Wetlands	Meadow marsh	Loamy clay	0,310	1,4	
22		Meadow chernozem solonetsous	Loamy clay	2,792	1,1	
23	Spring Wheat	Meadow	Loamy clay	0,795	1,6	
24		Meadow marsh	Loamy clay	4,782	3,6	
25		Meadow marsh saline	Loamy clay	5,776	2,4	
26		Meadow solonets	Loamy clay	4,680	2,6	
27		Meadow solonetsous	Loamy clay	9,726	3,4	
28		Meadow chernozem solonetsous	Loamy clay	8,421	2,7	
29		Leached chernozem	Medium-textured loam	51,360	2,1	
30		Solod	Medium-textured loam	0,540	1,8	
31		Grey forest solodized	Sandy loam	9,321	1,6	
			Total:	176,788		

31 unique RFS have been identified through the overlay of the three maps. The catchment is dominated by the following types of land use: spring wheat (53.96%), deciduous forest (23.72%) and summer pasture (11.61%). Large areas of spring wheat and summer pasture cause high nutrient concentrations in the research area, which were detected by sampling in 2013. The slope of the territory varies slightly and has low effect on runoff distribution. Texture of soils in most cases loamy clay, which promotes nutrient accumulation in the soils.

Discussion and Outlook

The results obtained are the first stage of work on the modeling of nutrient concentrations in the river Loktinka. Information derived at this stage is essential and it will be the basis of the second stage - the calculation of nutrient removal from the catchment, and from each Runoff Forming Surface (RFS).

PROMOTION

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